PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference MK/DM/P13427PC	**FOR FURTHER ACTION** See Form PCT/IPEA/416	
International application No. PCT/GB2004/001129	International filing date *(day/month/year)* 16.03.2004	Priority date *(day/month/year)* 18.03.2003
International Patent Classification (IPC) or national classification and IPC H04L27/26		
Applicant UNIVERSITY COURT OF GLASGOW CALEDONIAN UNIVERSITY		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 9 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 13 sheets, as follows:
      - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

Date of submission of the demand 13.01.2005	Date of completion of this report 31.05.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Marselli, M Telephone No. +31 70 340-4117

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-51 as originally filed

Claims, Numbers

1-57 received on 21.01.2005 with letter of 18.01.2005

Drawings, Sheets

1/24-24/24 as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☒ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☒ the claims, Nos. 58-67
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	5-11 14 16-18 23-28 32-35 40-46 50-53
	No:	Claims	1-4 12-13 15 19-22 29-31 36-39 47-49 54-57
Inventive step (IS)	Yes:	Claims	5 7-11 17 23 25-28 34 40 42-46 52
	No:	Claims	1-4 6 12-16 18-22 24 29-33 35-39 41 47-51 53-57
Industrial applicability (IA)	Yes:	Claims	1-57
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Documents

1.1 The following documents are referred to in this report:

D1: WO 93/09622 A (MOTOROLA INC) 13 May 1993 (1993-05-13)

D2: EP-A-0 752 779 (NOKIA MOBILE PHONES LTD ; NOKIA TELECOMMUNICATIONS OY (FI)) 8 January 1997 (1997-01-08)

2. Novelty and Inventive Step - Article 33(2) PCT - Article 33(3) PCT

2.1 The present application does not meet the requirements of Article 33(1) PCT, because the subject-matter of independent **claims 1 and 19, 36, 54, and 56** is not novel in the sense of Article 33(2) PCT.

Using the terminology of **claim 1** of the present application, **document D2** discloses (the references in parentheses applying to this document):

a method for encoding data for transmission over a telecommunications network (column 3, lines 24-25, transmission of frames in a DAB system) comprising embedding a control data block within a plurality of real data blocks (column 3, lines 25-27; fig. 2a, symbols "OS1" in the left column); convoluting real data in each real data block with at least some of the control data in the control data blocks (column 3, line 10, equation 1: the content of the l-th OFDM block involves convoluting the l-1-th OFDM block with the l-th data block; going back in the chain, this involves the convolution of the previous data blocks with the phase reference symbol at the beginning); modulating or transforming the convoluted real data in the real data blocks with one or more sub-carrier signals (fig. 2a: OFDM transmission of the symbols following the "OS1" symbol); and modulating or transforming data in the

control data block with every sub-carrier that is used to modulate the real data (fig. 2a: OFDM transmission of symbol "OS1").

2.2 The Applicant's attention is drawn to the complex multiplication in **document D2**, column 3, line 10, equation 1: $z_{l,k}=z_{l-1,k}y_{l,k}$ where $z_{l,k}$ is the content of the OFDM symbol l at subfrequency k, $z_{l-1,k}$ is the content of the OFDM symbol l-1 at the same subfrequency k, and $y_{l,k}$ is the input data symbol. Let us suppose that symbol l=0 is the control data symbol, followed by information data symbols for l=1,2,3,... We have:
$z_{0,k}=c_{0,k}$ is the control data symbol (i. e. "OS1" in fig. 2a);
$z_{1,k}=c_{0,k}y_{1,k}$ is the first convoluted data symbol; as it is here now clear, calculating the phase of each entry of the first transmitted symbol involves adding the phase of each entry of the control data symbol with the phase angle of the corresponding entry of the first information data block;
$z_{2,k}=c_{0,k}y_{1,k}y_{2,k}$ is the second convoluted data symbol; calculating the phase of each entry of the second transmitted symbol involves adding the phase of each entry of the control data symbol with the phase angle of the corresponding entries of the first and second information data block;
$z_{3,k}=c_{0,k}\, y_{1,k}\, y_{2,k}\, y_{3,k}$ is the third convoluted data symbol; calculating the phase of each entry of the third transmitted symbol involves adding the phase of each entry of the control data symbol with the phase angle of the corresponding entries of the first, second and third information data block;
it is now clear that calculating the phase of each entry of the n-th transmitted symbol involves adding the phase of each entry of the control data symbol with the phase angle of the corresponding entry of the n-th information data block, plus the entries of the previous data blocks.

The subject-matter of **claim 1** is therefore not novel (Article 33(2) PCT).

2.3 The same reasoning applies, mutatis mutandis, to the subject-matter of **claims 19, 36, 54, and 56.**

2.4 Dependent **claims 2-4, 6, 12-15, resp. 20-22, 24, 29-31, resp. 37-39, 41, 47-49, resp. 55** do not contain any additional features which, in combination with the features of **claim 1, resp. 19, resp. 36, resp. 54** are new or involve an inventive step.

The subject-matter of **claims 2, resp. 20, resp. 37, resp. 55** is disclosed in **document D2**, figure 2a, where five different subcarriers are shown (that is, m=5).
The subject-matter of **claims 3-4, resp. 21-22, resp. 38-39** is disclosed in **document D2**, column 3, equation 1 and lines 24-37: the phase of the phase reference symbol is added to all the following symbols of that frame (see item 2.2).
The subject-matter of **claim 6, resp. 24, resp. 41** is not inventive as the assignment of the phase reference symbol is considered a simple design option, which comes within the scope of the customary practice followed by the persons skilled in the art.
The subject-matter of **claim 12** is implicit in the OFDM modulation.
The subject-matter of **claim 13, resp. 29, resp. 47** is disclosed in **document D2**, column 3, lines 29-37 and figure 2a.
The subject-matter of **claim 14, resp. 30, resp. 48** is not inventive as the placement of reference symbols in the middle of the frame is a well-known technique in the telecommunications field; for instance, the GSM technique uses a midamble placed in the middle of the frame.
The subject-matter of **claim 15, resp. 31, resp. 49** is disclosed in **document D2**, fig. 2a: the pilot symbols are represented by the "OS1" symbols.

2.5 The combination of the features of dependent **claims 5, resp. 23, resp. 40 or 7-11, resp. 25-28, resp. 42-46** is neither known, nor rendered obvious by, the available prior art.

Claim 5 defines a method wherein only the phase angle of the control data block is added to the original phase angles of the information data blocks, so as to make possible the decoding of a received symbol without detection of the previous symbol. The same reasoning applies for **claims 23 and 40.**
Claims 7-11 define methods wherein the control data block has a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks, so as to reduce the crest factor by design of random carrier phases. The same reasoning applies for **claims 25-28 and 42-46.**

2.6 Using the terminology of **claim 16** of the present application, **document D2** discloses (the references in parentheses applying to this document):

a method for decoding data received over a telecommunications network (column 10, lines 14-16; column 3, line 24; reception of DAB frames), the method comprising: receiving a modulated control block embedded in a plurality of modulated convoluted real data blocks (column 3, lines 25-27; fig. 2a, symbols "OS1" in the left column), each convoluted data block being a convolution of at least some control data in an original version of the control data blocks and an original version of the real data (column 3, line 10, equation 1: the content of the l-th OFDM block involves convoluting the l-1-th OFDM block with the l-th data block; going back in the chain, this involves the convolution of the previous data blocks with the phase reference symbol at the beginning),

The subject-matter of **claim 16** differs from that in **document D2** in that:

identifying the received control data block, and estimating the data in each of the original real data blocks by dividing each entry of the received real data blocks with the corresponding entry of the control data block.

The problem to be solved by the present invention may therefore be regarded as how to estimate the received data blocks. The solution proposed in **claim 1** of the present application cannot be considered as involving an inventive step (Articles 33(1) and 33(3) PCT) because the missing features come within the customary practice commonly followed when decoding differentially transmitted data. The skilled person would therefore regard it as a normal design option to include these features in the method described in **document D2** in order to solve the problem posed.

The Applicant's attention is drawn to the fact that, in a differential receiver, data are detected by inverting the equation 1 in **document D2**, column 3, that is, one normally has: $y_{l,k}=r_{l,k}/r_{l-1,k}$ where $y_{l,k}$ is the detected information data symbol, $r_{l,k}$ is the content of the received OFDM symbol l at subfrequency k, $r_{l-1,k}$ is the content of the OFDM symbol l-1 at the same subfrequency k. Now, for the case l=1,2,... the inverted equation gives:
$y_{1,k}=r_{1,k}/c_{0,k}$ wherein $c_{0,k}$ is the received control data symbol (i. e. "OS1" in fig. 2a);
$y_{2,k}=r_{2,k}/r_{1,k}=r_{2,k}/(y_{1,k}c_{0,k})$ wherein $c_{0,k}$ is the received control data symbol;
As the equation applies for every value of l, in a way similar to that described under

item 2.2, it is now clear that estimating the information data in each of the original information data blocks involves dividing each entry of the received data symbol with the corresponding entry of the control data symbol.

The subject-matter of **claim 16** is therefore not inventive (Article 33(1) and (3) PCT).

2.7 The same reasoning applies, mutatis mutandis, to the subject-matter of **claims 32, 50 and 56.**

2.8 Dependent **claims 18, resp. 33, 35, resp. 51, 53** do not contain any additional features which, in combination with the features of **claim 16, resp. 32, resp. 50** are new or involve an inventive step.

The subject-matter of **claims 18, resp. 35, resp. 53** is implicitly disclosed in any OFDM receiver making use of control symbols.

The subject-matter of **claim 33, resp. 51** is not inventive as the additional features defined therein, are disclosed in **document D2**, column 3, equation 1 and lines 29-37.

2.9 The combination of the features of dependent **claims 17, resp. 34, resp. 52** is neither known, nor rendered obvious by, the available prior art.

Claim 17 defines a method wherein an algorithm for decoding the transmitted information data is provided, which does not require to detect the previous symbol in order to decode the presently received data symbol. The same reasoning applies to dependent **claims 34, resp. 52.**

2.10 Dependent **claim 57** does not contain any additional features which, in combination with the features of **claims 56** is new or involves an inventive step.

The subject-matter of **claim 57** is disclosed in **document D2** as the transmitting and receiving devices therein described are clearly telecommunication devices.

Re Item VIII

Certain observations on the international application

1. **Clarity - Article 6 PCT**

1.1 **Claims 19 and 36** have been drafted as separate independent claims.

According to Article 6 PCT, an application may contain more than one independent claim in a particular category only if the subject matter claimed falls within exceptional situations. This is however not the case in the present application as the two aforementioned independent claims overlap to a large extent.

1.2 The same objection applies to **claims 32 and 50.**

1.3 The device claimed in **claim 56** includes a reference to a computer program in its last sentence:

...and computer program...

In the PCT procedure, claims to a device are regarded as claims to apparatuses and not as claims to computer programs. Thus, in order to meet the requirements of Article 6 PCT with respect to clarity, the device claimed in **claim 56** should not contain references to computer programs.

Claims

1. A method for encoding data for transmission over a telecommunications network comprising embedding a control data block within a plurality of real data blocks; convoluting real data in each real data block with at least some of the control data in the control data blocks; modulating or transforming the convoluted real data in the real data blocks with one or more sub-carrier signals; and modulating or transforming data in the control data block with every sub-carrier that is used to modulate the real data.

2. A method as claimed in claim 1, wherein each of the control and real data blocks has *m* entries, where *m* is an integer of one or more, and *m* sub-carrier transmission channels are provided, and each control data entry and each real data entry are modulated with the corresponding sub-carrier.

3. A method as claimed in claim 1 or claim 2, wherein the step of convoluting involves phase angle convoluting each entry in each real data block with a phase angle of the corresponding entry in the control block.

4. A method as claimed in claim 3, wherein the step of phase angle convoluting involves adding the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

5. A method as claimed in claim 4, wherein the convoluted encoded data blocks can be represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded

quadrature signal in data block n for sub-carrier m; ϕ_{nm0} is the original phase angle for data block n and sub-carrier m; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier m.

6. A method as claimed in any of the preceding claims, wherein each phase angle for the control data in the control data block is randomly assigned.

7. A method as claimed in any of claims 1 to 6, wherein each entry of the control data block has a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

8. A method as claimed in claim 7, wherein the phase angle of each entry of the control data block is the sum of the phase angles of the corresponding entries of real data blocks.

9. A method as claimed in claim 8, comprising phase angle convoluting each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

10. A method as claimed in claim 9, wherein the step of convoluting comprises subtracting from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

11. A method as claimed in claim 10, when dependent directly or indirectly on claim 9, wherein the encoding of an N block data transmission can be represented as

follows:

$$X_{1m0} = I^c_{1m0} + jQ^c_{1m0} = A_{1m0}\exp\left(j\left(\alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \alpha_{3m}\phi_{3m0} - \quad \ldots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

$$X_{2m0} = I^c_{2m0} + jQ^c_{2m0} = A_{2m0}\exp\left(j\left(\alpha_{2m}\phi_{2m0} - \alpha_{1m}\phi_{1m0} - \alpha_{3m}\phi_{3m0} - \quad \ldots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{km0} = I^c_{km0} + jQ^c_{km0} = A_{km0}\exp\left(-j\left(\alpha_{1m}\phi_{1m0} + \alpha_{2m}\phi_{2m0} + \alpha_{3m}\phi_{3m0} + \quad \ldots \quad + \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{Nm0} = I^c_{Nm0} + jQ^c_{Nm0} = A_{Nm0}\exp\left(j\left(\alpha_{Nm}\phi_{Nm0} - \alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \quad \ldots \quad - \alpha_{(N-1)m}\phi_{(N-1)m0}\right)\right)$$

where the terms α_{nm} *(n = 1, 2 ...N)* are constants associated with the convolution of each encoded phase angle on the sub-carrier.

12. A method as claimed in any of the preceding claims, wherein the step of modulating comprises frequency modulating the signal.

13. A method as claimed in any of the preceding claims comprising receiving data for transmission to a receiver, dividing the data into *N-1* data blocks and embedding a the control data block into the *N-1* data blocks to provide a *N* block data transmission.

14. A method as claimed in any of the preceding claims wherein the control data block is embedded substantially in the middle of the real data blocks.

15. A method as claimed in any of the preceding claims wherein a plurality of control data blocks are embedded within the real data blocks.

16. A method for decoding data received over a telecommunications network, the method comprising: receiving a modulated control block embedded in a plurality of modulated convoluted real data blocks, each convoluted data block being a convolution of at least some control data in an original version of the control data blocks and an original version of the real data, identifying the received control data block, and estimating the data in each of the original real data blocks by dividing each entry of the received real data blocks with the corresponding entry of the control data block.

17. A method as claimed in claim 16, wherein the original data blocks were phase convoluted using the phase angles of the original control data block and the step of estimating uses the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km} + Q_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm} - I_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

18. A method as claimed in claim 16 or claim 17

comprising receiving a serial stream of data and re-constructing from this the modulated control block and the plurality of modulated data blocks.

19. An encoder for encoding data for transmission over a telecommunications network, the encoder being configured to: embed a control data block within a plurality of real data blocks; convolute real data in each real data block with at least some of the control data in the control data blocks; modulate or transform the convoluted real data in the real data blocks with one or more sub-carrier signals; and modulate or transform data in the control data block with every sub-carrier that is used to modulate the real data.

20. An encoder as claimed in claim 19, wherein each of the control and real data blocks has m entries, where m is an integer of one or more, and m sub-carrier transmission channels are provided, and each control data entry n, where $n = 1 \ldots m$, and each real data entry n are modulated with the corresponding sub-carrier n.

21. An encoder as claimed in claim 20 configured to phase angle convolute each entry in each real data block with a phase angle of the corresponding entry in the control block.

22. An encoder as claimed in claim 21 configured to add the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

23. An encoder method as claimed in claim 22, wherein

the convoluted encoded data blocks can be represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded quadrature signal in data block n for sub-carrier m; ϕ_{nm0} is the original phase angle for data block n and sub-carrier m; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier m.

24. An encoder as claimed in any of claims 19 to 23, wherein each phase angle for the control data in the control data block is randomly assigned.

25. An encoder as claimed in any of claims 19 to 24, configured to assign to each entry of the control data block a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

26. An encoder as claimed in claim 25, wherein the phase angle of each entry of the control data block is the sum of the phase angles of the corresponding entries of real data blocks.

27. An encoder as claimed in claim 26 configured to phase angle convolute each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

28. An encoder as claimed in claim 27 configured to convolute the phase angles by subtracting from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

29. An encoder as claimed in any of claims 19 to 28 configured to receive data for transmission, divide the data into *N-1* data blocks and embed the control data block into the *N-1* data blocks to provide a N block data transmission.

30. An encoder method as claimed in any of claims 19 to 29 configured to embed the control data block substantially in the middle of the real data blocks.

31. An encoder as claimed in any of claims 19 to 30 configured to embed a plurality of control data blocks within the real data blocks.

32. A decoder for decoding data received over a telecommunications network configured to receive a modulated control block embedded in a plurality of modulated convoluted data blocks, each convoluted data block being a convolution of at least some control data in an original version of the control data blocks and an original version of the real data, identify the received control data block, and estimate the data in each of the original data blocks by dividing each entry of the received modulated convoluted real data blocks with the corresponding entry of the control data block.

33. A decoder as claimed in claim 32, wherein the original data blocks were phase convoluted using the phase angles of the original control data block.

34. A decoder as claimed in claim 33 operable to estimate the data using the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km} + Q_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm} - I_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

35. A decoder as claimed in any of claims 32 to 34 configured to receive a serial stream of data and re-construct from this the modulated control block and the plurality of modulated data blocks.

36. A system for encoding data for transmission over a telecommunications network comprising means for embedding a control data block within a plurality of real data blocks; means for convoluting real data in the real data blocks with at least some of the control data in the control data blocks; means for modulating or transforming data in the convoluted real data blocks with one or more sub-carrier signals; and means for modulating or transforming data in the control data block with every sub-carrier that is used to modulate the real data.

37. A system as claimed in claim 36, wherein each of the control and real data blocks has m entries, where m is an integer of one or more, and m sub-carrier transmission

channels are provided, and each control data entry and each real data entry are modulated with the corresponding sub-carrier.

38. A system as claimed in claim 36 or claim 37 wherein the means for convoluting are operable to phase angle convolute each entry in each real data block with a phase angle of the corresponding entry in the control block.

39. A system as claimed in claim 38, wherein the means for phase angle convoluting are operable to add the phase angle of each entry of the control data block to the phase angle of the corresponding entry of each real data block.

40. A system as claimed in claim 39, wherein the convoluted encoded data blocks are represented by: $X_{nm}=A_{nmo}exp(j(\phi_{nmo}+\phi_{kmo})$, where X_{nmo} is the original encoded quadrature signal in data block n for sub-carrier m; ϕ_{nm0} is the original phase angle for data block n and sub-carrier m; and ϕ_{km0} is the original phase angle for the control data block and sub-carrier m.

41. A system as claimed in any claims 36 to 40 comprising means for randomly assigning each phase angle for the control data in the control data block.

42. A system as claimed in any of claims 36 to 41, wherein each entry of the control data block has a phase angle that is a function of the phase angles of the corresponding entries of the real data blocks.

43. A system as claimed in claim 42, wherein the means

for convoluting are operable to sum of the phase angles of corresponding entries of the real data blocks and assign that sum as the phase angle for the corresponding control data.

44. A system as claimed in claim 42 or claim 43, comprising means for phase angle convoluting each entry of each data block with the phase angles of the corresponding entries of the other real data blocks.

45. A system as claimed in claim 44, wherein the means for convoluting the real data are operable to subtract from the phase angle of each real data entry all of the phase angles of all of the corresponding entries of all of the other real data blocks.

46. A system as claimed in claim 45 wherein the encoding of an N block data transmission can be represented as follows:

$$X_{1m0} = I^c_{1m0} + jQ^c_{1m0} = A_{1m0}\exp\left(j\left(\alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \alpha_{3m}\phi_{3m0} - \quad \dots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

$$X_{2m0} = I^c_{2m0} + jQ^c_{2m0} = A_{2m0}\exp\left(j\left(\alpha_{2m}\phi_{2m0} - \alpha_{1m}\phi_{1m0} - \alpha_{3m}\phi_{3m0} - \quad \dots \quad - \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{km0} = I^c_{km0} + jQ^c_{km0} = A_{km0}\exp\left(-j\left(\alpha_{1m}\phi_{1m0} + \alpha_{2m}\phi_{2m0} + \alpha_{3m}\phi_{3m0} + \quad \dots \quad + \alpha_{Nm}\phi_{Nm0}\right)\right)$$

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$$X_{Nm0} = I^c_{Nm0} + jQ^c_{Nm0} = A_{Nm0}\exp\left(j\left(\alpha_{Nm}\phi_{Nm0} - \alpha_{1m}\phi_{1m0} - \alpha_{2m}\phi_{2m0} - \quad \dots \quad - \alpha_{(N-1)m}\phi_{(N-1)m0}\right)\right)$$

where the terms α_{nm} $(n = 1, 2 \dots N)$ are constants associated with the convolution of each encoded phase angle on the sub-carrier.

47. A system as claimed in any of claims 36 to 46 comprising means for receiving data for transmission; means for dividing the data into *N-1* data blocks and means for embedding the control data block into the *N-1* data blocks to provide a *N* block data transmission.

48. A system as claimed in any of claims 36 to 47 wherein the control data block is embedded substantially in the middle of the real data blocks.

49. A system as claimed in any of claims 36 to 48 wherein the means for embedding the control data block are operable to embed a plurality of such control data blocks within the real data blocks.

50. A system for decoding data received over a telecommunications network, the system comprising: means for receiving a modulated control block embedded in a plurality of modulated data blocks, each convoluted data block being a convolution of at least some control data in an original version of the control data blocks and an original version of the real data; means for identifying the received control data block, and means for estimating the data in each of the original data blocks by dividing each entry of the received modulated convoluted real data blocks with the corresponding entry of the control data block.

51. A system as claimed in claim 50, wherein the original data blocks were phase convoluted using the phase angles of the original control data block.

52. A system as claimed in claim 50 or 51 wherein the means for estimating are operable to use the following algorithms:

$$\hat{I}_{nm} = A_{km0}\frac{(I_{nm}I_{km} + Q_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\cos\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

$$\hat{Q}_{nm} = A_{km0}\frac{(I_{km}Q_{nm} - I_{nm}Q_{km})}{(I_{km}^2 + Q_{km}^2)} = \hat{A}_{nm}\sin\hat{\phi}_{nm} \qquad n = 1, 2, \ldots N\ (n \neq k)$$

where A_{km0} is a known control value; I_{nm} and Q_{nm} are the demodulated components of the m sub-carriers of the N data blocks in the presence of attenuation and/or channel distortion; and I_{km} and Q_{km} are the demodulated components of the m sub-carriers of the control data block in the presence of attenuation and/or channel distortion in the presence of attenuation and channel distortion.

53. A system as claimed in any of claims 50 to 52 comprising means for receiving a serial stream of data and means for re-constructing from this the modulated control block and the plurality of modulated data blocks.

54. A computer program, preferably on a data carrier or a computer readable medium, having code or instructions for encoding data for transmission over a telecommunications network, the program comprising embedding a control data block within a plurality of real data blocks; convoluting real data in the real data blocks with at least some of the control data in the control data blocks; modulating or transforming real data in the convoluted real data blocks with one or more sub-carrier signals; and modulating or transforming data in the control data block with every sub-carrier that is

used to modulate the real data.

55. A computer program as claimed in claim 54, wherein each of the control and real data blocks has *m* entries, where *m* is an integer of one or more, and *m* sub-carrier transmission channels are provided, and each control data entry and each real data entry are modulated with the corresponding sub-carrier.

56. A device that includes any one of an encoder, decoder, a system and computer program as claimed in any of claims 19 to 55.

57. A device as claimed in claim 56, the device being any telecommunications device, such as a personal mobile communications device or mobile/radio telephone or a computer with telecommunications capabilities or a digital broadcast radio or a digital television or set top box or any wireless networked device.